National Institute of Technology Rourkela

Department of Computer Science and Engineering

B.Tech/Dual Degree 5th Semester

End Semester Examination (Spring) 2019

Subject: **Formal Languages and Automata Theory** Subject Code: **CS 2004**

Full Marks: **50** Duration: **3 Hours**

Answer ***ALL*** questions.

Figures at the right margin indicate marks.

All parts of a question must be answered at one place.

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1. (a) Draw the state transition diagram for a Turing machine which recognises the language L= $\{0^{2^n}\}$ for all $n \geq 0$. [5]

   (b) Design a DFA (deterministic finite automaton) to accept the language [5]
   $L1 = \{\alpha \in \{a, b, c\}^* | \alpha$ starts and ends with the same symbol $\}$. Only draw the transition diagram, and clearly indicate the start state and the final state(s).

2. (a) Find the CFG for the following languages: [5]
   i. $L1 = \{a^n b^m | n \neq 2m\}$
   ii. $L2 = \{a^n b^m c^k | n = m$ or $m \leq k\}$

   (b) Design a PDA for the language L=$\{w \in \{a, b, c\}^* | n_a(w) + n_b(w) = n_c(w)\}$. [5]

3. (a) Design a Turing Machine over the alphabet $\{a, b, c\}$ to accept all palindromes. [4]

   (b) Define Pumping Lemma for context-free languages.Let $\Sigma = \{0, 1, \#\}$ and define a language C over Σ as follows: [4]
   C =$\{r\#s \mid r, s \in \{0, 1\}^*, r$ is a substring of s$\}$.
   The language C is not context-free.

   (c) What language does the PDA in Figure 1 depict? [2]

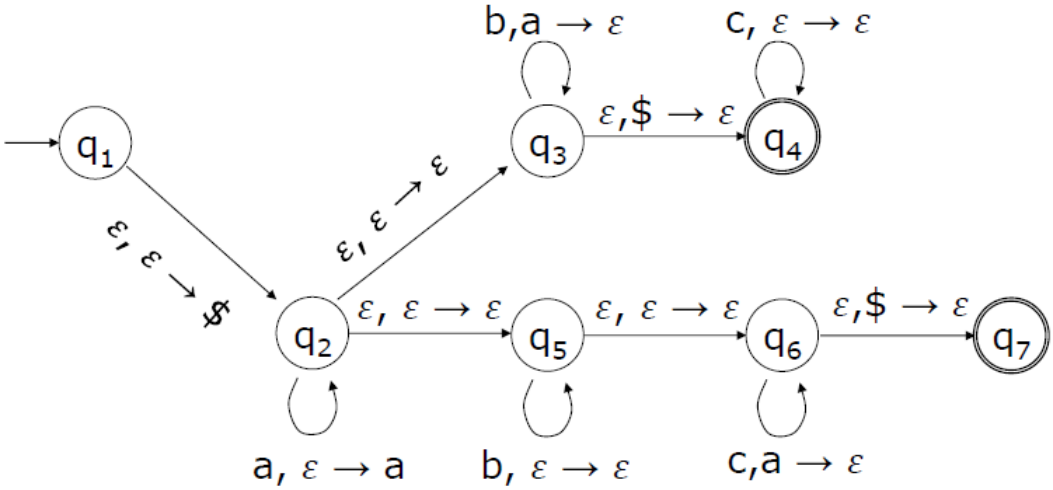

Figure 1:

4. (a) Draw the state transition diagram of the language accepted by a DFA whose equivalent PDA P $= (\{p, q\}, \{a, b\}, \{R, Z_0\}, \delta, q, Z_0)$ if δ is given by: [4]
$\delta(q_0, b, Z_0) = \{(p, RZ_0)\}$
$\delta(p, a, R) = \{(q_0, \epsilon)\}$
$\delta(q_0, \epsilon, Z_0) = \{(p, \epsilon)\}$

   (b) What is left recursive and right recursive grammars? With an example explain how to convert a given left recursive grammar to its equivalent grammar without left recursive productions. [4]

   (c) Consider the grammar [2]
$S \rightarrow xSyS \mid SS \mid \lambda$
What language does it generate?

5. (a) What do you mean by a context-free grammar? Explain with suitable examples, how to eliminate ϵ-**production**, **unit production** and **useless symbols** from a grammar. [4]

   (b) Find a context free grammar with minimum number of production rules possible for the language given below and also, construct the PDA. [4]
$\{1^q 1^{m+n} 1^n 0^p 0^{p+q} 0^q \mid m, n, p, q \geq 0\}$

   (c) Construct a deterministic finite automaton equivalent to the grammar [2]
$S \rightarrow aS|bS|aA$
$A \rightarrow bB$
$B \rightarrow aC$
$C \rightarrow \in$

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